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ANtarctic geological DRILLing (ANDRILL) Program

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Abstract

The ANDRILL (Antarctic geological DRILLing) Program (IPY Project #256) is an international effort involving scientists from Germany, Italy, New Zealand and the United States. The ANDRILL Program is designed to investigate Antarctica's role in global environmental change through the recovery of rock and sediment cores from beneath the sea ice and ice shelves surrounding Antarctica. ANDRILL uses improved drilling technology that enables excellent recovery of deep (>1000 meters below sea floor) rock and sediment cores from the Antarctic margin. The start of the International Polar Year (IPY) provides an important opportunity to initiate new discussions with international scientists and their respective funding agencies to develop future collaborations related to ANDRILL.

1. Introduction

The ANDRILL (ANtarctic geological DRILLing) Program, which is endorsed as International Polar Year (IPY) Project #256, is a new, exciting and ambitious drilling program that builds on the legacy of international efforts to recover important geological and climate records that are preserved beneath Antarctica's blanket of ice.

Fig. 1. ANDRILL Logo.

The program's primary objectives are to investigate Antarctica's role in global environmental change over the past 65 million years at various scales of age resolution. New stratigraphic records from Antarctica will enhance our ability to understand Antarctica's potential response to future global changes. A key motivation for undertaking this multi-national, multi-disciplinary program stems from a lack of knowledge about the complex roles the Antarctic cryosphere (ice sheets, ice shelves and sea ice) played in the global climate system in the past.

The ANDRILL Program recognizes that efforts to understand the role of Antarctic drivers on global climate variability require a fundamental knowledge of Antarctic cryospheric evolution, not only in recent times, but also for times in the past when global temperatures and atmospheric carbon dioxide levels were similar to what may be reached by the end of this century.

ANDRILL's integrated science approach uses stratigraphic drilling and multi-proxy core analysis combined with geophysical surveys and numerical modeling to address: (1) thresholds and stages in the development of the cryosphere; (2) climatic optima and ice sheet stability; (3) ice sheet modulation of global climate and sea level; (4) origins and adaptations of polar biota; and (5) West Antarctic Rift and uplift of the Transantarctic Mountains.

International funding for ANDRILL from Germany, Italy, New Zealand, and the United States supported the development of a new dedicated drilling system and drill camp to enable the completion of the two inaugural ANDRILL projects, the McMurdo Ice Shelf (MIS) Project, which was drilled in late 2006, and the Southern McMurdo Sound (SMS) Project, which will be drilled in late 2007. The scientific prospectus and other information about each of these two ANDRILL projects, as well as education and public outreach materials and publications, are available at: <http://andrill.org>. Research on these projects will be conducted during the International

Polar Year (2007-2009) and outcomes will be highlighted at: <http://www.ipy.org>.

Fig. 2. McMurdo Ice Shelf (MIS) Project logo.

2. ANDRILL Management

The two inaugural ANDRILL projects - the MIS and SMS projects – are overseen by the McMurdo-ANDRILL Science Implementation Committee (M-ASIC) and the ANDRILL Operations Management Group (AOMG), whose directions are implemented through the ANDRILL Science Management Office (SMO) at the University of Nebraska-Lincoln and the Project Operator's Office within Antarctica New Zealand, respectively. The ANDRILL Science Committee (ASC) provides for long-term planning, with input from technical advisory panels. Future ANDRILL projects will depend on new proposals to national funding agencies. Ongoing and future community involvement and proposal/site development is activity encouraged, facilitated and coordinated by the ASC and the SMO. A call for letters of interest for future ANDRILL projects will be issued in early 2007 to coincide with the start of the International Polar Year (IPY).

3. The Drilling System

The ANDRILL Program built a state-of-the-art drilling system designed to recover sediment and rock core from regions of Antarctica where these records were previously inaccessible. The ability to use either fast-ice or shelf-ice as a drilling platform allows sampling from a wide range of marine environments surrounding Antarctica. The drilling system, based on technology proven during the Cape Roberts Project (1995-2000), has the capability to penetrate through >250 meters of ice, floating on >1000 meters of water, and is able to recover strata (soft sediment and bedrock) to greater than 1000 meters below the sea-floor (i.e., a total drill string length of up to 2500 meters), with a high-percentage of core recovery (>90%).

The ANDRILL drilling system is built around a type of drilling rig, constructed by UDR (Brisbane, Australia), that is commonly used in minerals mining, but has been customized for ANDRILL scientific requirements and for Antarctic conditions in the following ways: (1) reconfiguration of the main winch for a double line pull to deploy sea-riser casing, which weighs up to 30 tons; (2) tide compensation to allow for up to 1.5 meters of vertical tidal movement of the ice shelf or sea-ice platform; (3) the addition of an enclosure to provide a warm environment for workers and equipment on the drill floor; and (4) separation of the rig hydraulic power pack (in an insulated container) and the drill mast and winches to provide the best heated location. The entire system can be broken down into components allowing transport on sledges.

The design, engineering, construction and operational expertise for the drilling system are contracted through Antarctica New Zealand from Victoria University of Wellington and Webster Drilling of New Zealand. The ANDRILL rig underwent thorough testing in Canterbury, New Zealand in late 2005 before it was shipped to Antarctica and reassembled near Scott Base in early 2006. The rig and drilling system was used for the MIS Project in the austral summer of 2006-2007 to recover core samples to a total depth of approximately 1285 mbsf, with an overall core recovery of 98%, which is a new Antarctic record.

Fig. 3. The ANDRILL Rig preparing for deployment to Antarctica.

4. ANDRILL Science and Logistics

The McMurdo Sound region was selected for the first phase of ANDRILL based on scientific and logistical considerations. The McMurdo region is close to existing Antarctic logistical centers, including McMurdo Station (U.S.) and Scott Base (N.Z.). The Crary Science and Engineering Center (CSEC, or Crary Laboratory) at McMurdo Station is a state-of-the-art science facility, where the bulk of the ANDRILL on-ice science is conducted.

The proximity of these facilities to the selected MIS and SMS drill sites minimizes logistical difficulties associated with operating a new drilling system in an extreme environment. Furthermore, access to Crary Laboratory allows ANDRILL projects to involve a full international scientific team to best achieve the comprehensive on-ice core characterization and analysis goals. Additional off-ice research and analysis of core materials is conducted at the home institutions of scientists involved in ANDRILL projects. Approximately 100 scientists, students, educators, technical assistants and members of the drilling team are involved in each project.

McMurdo Sound is located at the juncture of several components of the West Antarctic Rift System (WARS), including the Victoria Land Basin (VLB), Transantarctic Mountains (TAM), and Erebus Volcanic Province. The region is also currently situated near the confluence of several components of the Antarctic cryosphere, including the East and West Antarctic ice sheets, local alpine glaciers and sea ice.

As proven by the Cape Roberts Drilling Project, the proximity to the Transantarctic Mountains to McMurdo Sound, combined with ample accommodation space from tectonic subsidence of the Victoria Land Basin, provides excellent potential to preserve high-quality, time-continuous paleoenvironmental records, during times of both large and small Antarctic ice sheets. In some areas of McMurdo Sound, Neogene volcanism has produced local flexural-moat basins superimposed on the regional Victoria Land rift basin. These flexural moats provide both an ideal setting for sediment accumulation and a means of developing a high-resolution chronology from volcanic detritus.

The primary goal of the McMurdo Ice Shelf (MIS) Project (Naish et al., 2005; 2006) is to determine past ice shelf responses to climate forcing, including variability at a range of timescales. The first step toward achieving this outcome was taken from October 2006 to January 2007, when one hole was drilled to a total depth of 1285 meters below seafloor (mbsf) in the Windless Bight region of a flexural moat surrounding Ross Island. The preliminary results of this drilling will be forthcoming, and will be among the first results of the IPY. The Co-Chief Scientists for the ANDRILL MIS Project are Drs. Tim Naish (t.naish@gns.cri.nz) and Ross Powell (ross@geol.niu.edu).

The primary goal of the Southern McMurdo Sound (SMS) Project (Harwood et al., 2005) is to establish a robust history of Neogene Antarctic ice sheet variation and climate evolution that can be integrated into continental and global records. To achieve this outcome, one hole (>1000 mbsf) will be drilled in the austral summer of 2007 to sample an inferred middle Miocene to upper Miocene sequence of strata that extend basin-ward and are overlain by Pliocene to Pleistocene strata. This project will also be a highlight of the IPY. The Co-Chief Scientists for the ANDRILL SMS Project are Drs. David Harwood (dharwood1@unl.edu) and Fabio Florindo (florindo@ingv.it).

Specific objectives of these first two ANDRILL projects are to: (a) document the initial onset and subsequent history of sea-ice presence/absence; (b) document the evolution and demise of Neogene terrestrial vegetation; (c) establish a local late Neogene sea-level record; (d) test whether stable cold-polar climate conditions persisted for the last 15 million years before present; construct a composite history of glacial and interglacial events across a coastal to deep basin transect; (f) provide chronostratigraphic control for the regional seismic framework in the Victoria Land Basin and western Ross Sea; and (h) provide new paleoclimate data for ice sheet and climate models. All of these objectives will lead toward a better understanding of Antarctica's climatic and tectonic history.

5. Future Plans and Opportunities

ANDRILL has been conceptualized and planned as a long-term, cooperative international scientific effort that could involve many years of drilling. During the IPY we will be seeking additional international partnerships to fulfill the ANDRILL vision of recovering multiple high-quality geologic records from ice shelf and sea-ice platforms surrounding Antarctica.

The start of the International Polar Year (IPY) in March 2007 provides an important opportunity to initiate new discussions with international

scientists and their respective funding agencies to develop future collaborations in support of Antarctic geological drilling. The ANDRILL Science Committee (ASC) and McMurdo-ANDRILL Science Implementation Committee (M-ASIC), acting through the ANDRILL Science Management Office, welcome inquiries from international scientists and National Antarctic Program representatives seeking to submit proposals for scientific drilling from sea-ice or ice shelf platforms surrounding Antarctica, or to establish partnerships to advance ANDRILL's science themes through international collaboration.

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